OCEAN AND CLIMATE STUDIES

USAP's icebreaking research ship *Nathaniel B. Palmer* in the sea ice.
(NSF photo)

Though it borders the world's major oceans, the Southern Ocean system is like no other in the world, with four times more water than the Gulf Stream, 400 times more than the Mississippi River. It is a sea where average temperatures don't reach 2°C in summer, where even the water itself is so distinctive that it can be identified thousands of miles away in currents that originated here. These Antarctic Bottom Waters provide the major source of cooling for the world's oceans. In fact, if the earth is a heat engine, Antarctica should be viewed as its circulatory cooling component.

The climate in Antarctica is also unique, linked as it is to the extreme conditions of the land and sea below the troposphere (the inner region of the atmosphere, up to between 11 and 16 kilometers). This ocean/atmosphere environment defines and constrains the marine biosphere, and in turn has a dynamic relationship with the global ocean and with weather all over the planet. Few major energy exchanges on Earth can be calculated without factoring in these essential antarctic phenomena. As such, they are both an indicator and a component of climate change.

The Ocean and Climate Studies program sponsors research that will improve understanding of the high-latitude ocean environment, including the global exchange of heat, salt, water, and trace elements; there is also an emphasis on sea-ice dynamics, as well as the dynamic behavior and atmospheric chemistry of the troposphere. Major program elements include:

• **Physical oceanography:** The dynamics and kinematics of the polar oceans; the interaction of such forces as wind, solar radiation, and heat exchange; water-mass production and modification processes; ocean dynamics at the pack-ice edge; and the effect of polynyas on ventilation.

• **Chemical oceanography:** The chemical composition of sea water and its global differentiation; reactions among chemical elements and compounds in the ocean; fluxes of material, within ocean basins and at their boundaries; and the use of chemical tracers to map oceanic processes across a range of temporal and spatial scales.

• **Sea-ice dynamics:** The material characteristics of sea ice, from the individual crystal level to the large-scale patterns of freezing, deformation, and melting.

• **Meteorology:** Atmospheric circulation systems and dynamics, including the energy budget; atmospheric chemistry; transport of atmospheric contaminants to the antarctic; and the role of large and mesoscale systems in the global exchange of heat, momentum, and trace constituents.

Abrupt climate change studies.
Martin Visbeck, Lamont-Doherty Earth Observatory.

High on the list of pressing issues for the science of climatology in the twenty-first century is deciphering rapid climate change. We know that human activities are changing the composition of the radiative active gases in the atmosphere - a basic component of Earth's climate system. But when you try to model the coupled climate system with its many inputs, you find unexpected phenomena strongly amplifying climatic perturbations and producing nonlinear responses. The science of chaos had its origins in meteorology.

Several processes in the high latitudes have been identified as possible causes of significant, or rapid, future climate change - deep convection in the southern oceans, which is coupled to the global ocean circulation; the waxing and waning of sea ice, with its impact on the planet's albedo; and changes of regime in coupled ocean/atmosphere phenomena.

Ongoing scientific observations can further our insight into the processes that are thought to play an important role, providing the data needed to develop, test, validate and surpass global climate models. Over time, this process of perfecting global climate models provides a better handle on how the overall system might respond. When maintained over a long time period, the data enable researchers to track the state of the climate system and establish the baseline necessary for any predictions.

This project fits into that larger context by collecting a series of long-term observations to

• monitor the outflow of Weddell Sea Bottom and Deep Water, as well as other components acknowledged as sensitive indicators of climate change in the Southern Ocean;

• analyze the historical data sets and coupled climate models for ice/ocean/atmosphere interactions, with emphasis on ocean-heat transport variability; and

• investigate how antarctic deep-water forms and varies and its role in large-scale circulation models.

This austral summer we will work from the R/V *Nathaniel B. Palmer* to recover and redeploy 3 instrument moorings that were originally deployed during cruise 99-3 of the R/V *Laurence M. Gould* near the South Orkney Plateau. Time permitting, we hope to occupy CTD/tracer stations along the track between the current meter sites. The CTDs record current, temperature, and salinity variables within 500 meters of the ocean bottom. We will also obtain water samples for current/temperature/density profiles and tracer chemistry, both at the moorings and between sites.(OO-124-O)

Longwave radiation processes on the antarctic plateau.
Stephen G. Warren and Von P. Walden, University of Washington.

Thermal infrared ("longwave") radiation is an important component in the energy balance between the atmosphere and Earth's surface. On the antarctic continent, radiation processes dominate the surface energy budget. In summer, the budget involves four terms - incoming solar radiation, reflected solar radiation, long-wave radiation emitted by the atmosphere, and long-wave radiation emitted by the snow surface. In winter, after the sun sets, the short-wave terms fall to zero. The emitted long-wave radiation increases with temperature, so the surface temperature is determined by the balance of radiation fluxes.

Our project entails an experimental study of long-wave radiation processes near the surface at Amundsen-Scott South Pole Station. We have been taking high-resolution spectral measurements of the long-wave radiation at the snow surface. A Fourier-transform Interferometer installed in late 2000 operated for a full year, and at the beginning of the 2001-2002 austral summer, we will remove our instruments and collect the recorded data. Supporting observations were also made of how temperature and humidity vary with height in the lower atmosphere, and of the ice crystals in the atmospheric boundary layer. The research has also included experiments on emission characteristics - of snow, of ice crystals in the atmosphere, of clouds, and of greenhouse gases near the surface.

The newly developing climatology of cloud properties relies on the determination of concurrent environmental conditions (such as cloud-base altitude, temperature, and humidity-structure), and the sizes and concentrations of ice crystals. This work, based on more detailed radiation processes, should, improve climate models.(OO-201-O)

Antarctic Meteorological Research Center (AMRC), McMurdo Station.
Charles Stearns, University of Wisconsin.

The Antarctic Meteorological Research Center (AMRC), one of three research centers in the Crary Science and Engineering Center at McMurdo Station, is a resource for meteorological research as well as a test bed for improving operational synoptic forecasting. The Man-Computer Interactive Data Access System (McIDAS) - a versatile computer-based system developed by the University of Wisconsin for organizing, manipulating, and integrating environmental data - forms the basis of AMRC. It captures the flow of antarctic meteorological information from polar-orbiting satellites, automatic weather stations, operational station synoptic observations, and research project data. It also receives environmental data products, such as weather forecasts, from outside Antarctica, and acts as a repository for existing archived data bases.

The AMRC was established in the 1992-93 austral summer season and consisted of work stations capable of manipulating and displaying Advanced Very High Resolution Radiometer data, based on the existing satellite-imagery-acquisition system. This was followed by the acquisition and integration of a system that provided data collection, data display and archiving, scientific applications, network communications, and remote user access.

The system currently produces the Antarctic Composite Infrared Image (ACII), a mosaic of images from four geostationary and three polar-orbiting satellites, and is used for both forecasting and research purposes. We also continue to generate products and support users.(OO-202-O)

Atmospheric oxygen variability in relation to annual-to-decadal variations in terrestrial and marine ecosystems.
Ralph F. Keeling, Scripps Institution of Oceanography.

Oxygen, the most abundant element on the Earth, comprises about a fifth of the atmosphere. But much of the Earth's oxygen resides in other chemical species (in water, rocks, and minerals) and, of course, in flora and fauna that recycle it (both directly and as carbon dioxide) through the processes of photosynthesis and respiration. Thus scientists are interested in measuring the concentration of molecular oxygen and carbon dioxide in air samples; our project includes a subset of sample collections being made at a series of baseline sites around the world.

These data should help to improve estimates of the processes whereby oxygen is cycled throughout the global ecosystem, specifically, through photosynthesis and atmospheric mixing rates; also improve predictions of the net exchange rates of carbon dioxide with biota, on land and in the oceans. An important part of the measurement program entails developing absolute standards for oxygen-in-air, to ensure stable long-term calibration. We are also conducting surveys of the oxidative oxygen/carbon ratios of both terrestrial- and marine-based organic carbon, hoping to improve the quantitative basis for linking the oxygen and carbon dioxide geochemical cycles.

These results should help enhance our understanding of the processes that regulate the buildup of carbon dioxide in the atmosphere and of the change processes - especially climate change - that regulate ecological functions on land and in the sea.(OO-204-O)

Isotopic measurements of atmospheric molecular hydrogen (H_2).
Paul Quay and Richard Gammon, University of Washington

Molecular hydrogen (H_2) is the second most abundant reactive gas in the troposphere, where photochemical reactions form, and destroy, formaldehyde (HCHO). Consequent to these processes other chemicals are cycled - carbon monoxide (CO), methane (CH_4), and non-methane hydrocarbons. Despite its central role, the global H_2 budget is currently balanced only to within about 50 percent. Scientists talk of one day using H_2 as an important source of energy, yet such work would seem to depend on a better understanding of its global budget. We are measuring isotopes in order to investigate the atmospheric hydrogen (H_2) budget.

Deuterium (^2H) studies provide a good tracer for this work and can indicate the relative importance, to the formation of H_2, of the soil versus photochemical sinks. We are measuring the ratio of deuterium to hydrogen:

• in marine locations,

• in areas where biomass is being burned,

• in the H_2 produced by the photolysis of HCHO, and

• during soil uptake of H_2.

This work should help to resolve the current discrepancies in the global budget of H_2, and enhance understanding of the significance of increasing concentrations of CO, CH_4, and H_2 in the troposphere. (OO-221-O)

Measurements of the size, shape, scattering-phase function, and extinction coefficient of ice crystals at Amundsen-Scott South Pole Station.
R. Paul Lawson, SPEC, Inc., Boulder, Colorado.

Clouds are both the cause and result of atmospheric phenomena; one of their primary roles is as a reflector of solar energy - coming both from space and radiated/reflected from the Earth. And what are clouds? Broadly, clouds form when rising damp air expands to the point that it approaches saturation. With nowhere else to go, water molecules condense onto any local, available aerosol particles - the aggregation becomes a cloud. A number of theoretical and experimental studies have demonstrated that a cloud particle's size as well as its shape - and specifically ice crystals - strongly determine how it will reflect and radiate light (and energy).

Looking especially at cirrus clouds (the patchier, wispier filaments that appear in bands across the sky), this project will classify cloud particles by size and shape and will also investigate the light-scattering properties of ice crystals in the atmosphere above Amundsen-Scott South Pole Station. In cooperation with an ongoing radiation transfer program, we will deploy two high-resolution, digital cloud-particle imagers. The particle images, concentrations, and size distributions will be processed on site. Our software permits us to reject artifacts, and to compute various size and shape parameters, scattering characteristics, and ice/water proportions.

These data will complement several concurrent experiments on the emission characteristics of snow, ice crystals in the atmosphere, and greenhouse gases near the surface. With measurements of such environmental conditions as cloud-base altitude, temperature, and humidity structure, our data should allow us to develop new algorithms to substantially improve representations of radiation processes in general circulation models. We also expect to enhance the climatology of cloud-particles and cloud properties. (OO-226-O)

Chlorine- and bromine-containing trace gases in the antarctic.
Reinhold A. Rasmussen and M.A.K. Khalil, Oregon Graduate Institution of Science and Technology.

Although the Earth's climate is a massively complex system, at certain levels of the atmosphere interactions are predictable. Disregarding the ubiquitous and dynamic water vapor, more than 99.9 percent of atmospheric molecules are either nitrogen, oxygen, or the chemically inert "noble gases" (chiefly argon). Scientists have confirmed this baseline medium as largely unchanged for several hundred million years. However, much of the atmospheric "action" - acid rain, ozone depletion, smog - comes from the reactive trace species, which occur in small amounts but precipitate many crucial chemical events. There are thousands of these, but fewer than 200 are commonly present in a typical volume of air. It is not known for how long and in what proportions these have been prominent actors in atmospheric chemistry.

Chlorofluorocarbons, for example, are one problematic species, but a suite of other airborne trace constituents to be found in atmospheric gases derive from both biogenic and anthropogenic sources. Scientists monitor them closely, as they have been implicated in depletion of the ozone layer over Antarctica, as well as in other alterations of the Earth's climate.

This project continues to investigate seasonal trends in trace gas concentrations, by collecting a year-long suite of air samples at Palmer Station. They will be analyzed at the Oregon Graduate Center for a number of trace components, especially chlorine- and bromine-containing species. This work contributes to a better understanding of the buildup of trace constituents, particularly those of high-latitude marine origin. (OO-254-O)

South Pole monitoring for climate change. Amundsen-Scott South Pole Station.
Dr. David Hofmann, Climate Monitoring and Diagnostics Laboratory, National Oceanic and Atmospheric Administration; South Pole Station.

The National Oceanic and Atmospheric Administration has been conducting studies to determine and assess the long-term buildup of trace atmospheric constituents that influence climate change and the ozone layer. Time-series analyses of long-term data provide insight into several phenomena of particular interest. These include:

• seasonal and temporal variations in greenhouse gases,

• stratospheric ozone depletion,

• transantarctic transport and deposition,

• the interplay of the trace gases and aerosols with solar and terrestrial radiation fluxes that occur on the polar plateau, and

• the development of polar stratospheric clouds over Antarctica.

Project scientists measure carbon dioxide, methane, carbon monoxide, stable isotopic ratios of carbon dioxide and methane, aerosols, halocarbons, and other trace constituents. Flask samples are collected and returned for analysis, while concurrent *in situ* measurements are made of carbon dioxide, nitrous oxide, selected halocarbons, aerosols, solar and terrestrial radiation, water vapor, surface and stratospheric ozone, wind, pressure, air and snow temperatures and atmospheric moisture. Air samples at Palmer Station are also collected.

These measurements allow us to determine the rates at which concentrations of these atmospheric constituents change; they also point to likely sources, sinks, and budgets. We also collaborate with climate modelers and diagnosticians to explore how the rates of change of these parameters affect climate. (OO-257-O)

Drake Passage expendable bathythermograph program.
Janet Sprintall, Scripps Institution of Oceanography.

The Antarctic Circumpolar Current (ACC) is a powerful force that drives waters in the Southern Ocean - four times as fast as the Gulf Stream, for example. The current is even stronger wherever the distance between Antarctica and neighboring land is narrowed. These are the so-called chokepoints, such as The Drake Passage off the tip of South America and the sea regions between Antarctica and both the Cape of Good Hope and Tasmania. To determine the fluctuations in the transport of the ACC, scientists deploy bottom pressure gauges and similar instruments; this data can then be ranged against currents in the subtropical and subpolar gyres, and viewed in the context of the wind field over the southern oceans. Specifically since 1996, scientists in this research project have been collecting data to characterize the water mass variability in the Drake Passage, to describe temperature and circulation variability in the Southern Ocean, and to define the role of the Southern Ocean in the global climate system.

Using high-density expendable bathyermographs (XBT) launched from the R/V *Laurence M. Gould*, we will measure current, temperature, and depth for seasonal and year-to-year temperature fluctuations in the upper ocean within the Drake Passage. Since the water changes more rapidly there, we will execute frequent casts across the Subantarctic, Polar, and ACC fronts. (OO-260-O)

Collection of atmospheric air for the NOAA/CMDL worldwide flask sampling network, Palmer Station. *Dr. David Hofmann, Climate Monitoring and Diagnostics Laboratory, National Oceanic and Atmospheric Administration, Palmer Station.*

The National Oceanic and Atmospheric Administration has been conducting studies to assess the long-term buildup of trace atmospheric constituents that influence climate change and the ozone layer. Time-series analyses of long-term data provide insight into several phenomena of particular interest. These include:

• seasonal and temporal variations in greenhouse gases,

• stratospheric ozone depletion,

• transantarctic transport and deposition,

• the interplay of the trace gases and aerosols with solar and terrestrial radiation fluxes that occur on the polar plateau.

Personnel at Palmer Station will collect air samples to be analyzed for carbon dioxide, methane, carbon monoxide, stable isotopic ratios of carbon dioxide and methane. Flasks will also be collected for analysis of halocarbons, nitrous oxide, and other trace constituents.

These measurements allow us to determine the rates at which concentrations of these atmospheric constituents change; they also point to likely sources, sinks, and budgets. We also collaborate with climate modelers and diagnosticians to explore how the rates of change of these parameters affect climate. (00-264-0)

Operation of an aerosol sampling system at Palmer Station.
Colin G. Sanderson, Environmental Measurements Laboratory, U.S. Department of Energy.

Radionuclides are atoms emitting radioactive energy, some of which occur naturally in the surface air. It is these - as well as nuclear fallout and any accidental releases of radioactivity - that the Environmental Measurements Laboratory's (EML) Remote Atmospheric Measurements Program (RAMP) is designed to detect and monitor. Since 1963 EML, as part of the U.S. Department of Energy, has run the Global Sampling Network to monitor surface air. The RAMP system provides on-site analysis in thirteen different locations around the world, including Palmer Station, Antarctica. Using a high-volume aerosol sampler, a gamma-ray spectrometer, and a link to the National Oceanic and Atmospheric Administration's ARGOS satellite system, we will continue sampling air at Palmer Station for anthropogenic radionuclides. (00-275-0)

Antarctic automatic weather station program: 1998-2001.
Charles Stearns, University of Wisconsin at Madison.

A network of nearly 50 automatic weather stations (AWS) has been established on the antarctic continent and several surrounding islands. These facilities were built to measure surface wind, pressure, temperature, and humidity. Some of them also track other atmospheric variables, such as snow accumulation and incident solar radiation.

Their data are transmitted via satellite to a number of ground stations and put to several uses, including operational weather forecasting, accumulation of climatological records, general research purposes, and specific support of the U.S. Antarctic Program - especially the LTER program at McMurdo and Palmer Stations. The AWS network has grown from a small-scale program in 1980 into a significant data retrieval system that is now extremely reliable, and has proven indispensable for both forecasting and research purposes. This project maintains and augments the AWS, as necessary. (OO-283-M) (OO-283-P) (OO-283-S)

Does iron fertilization lead to enhanced carbon sequestration?
Ken Buesseler, Woods Hole Oceanographic Institution.

While it is demonstrated that adding iron (which often migrates on wind-borne dust) can stimulate phytoplankton growth and alter biogeochemistry in the upper ocean, we know little about how iron affects sinking particle fluxes. Two questions present themselves:

• Did iron play an important role in past climatic variations in carbon dioxide (CO_2)?

• If ocean ecosystems were to be deliberately manipulated in the future - iron fertilization has been proposed to offset carbon dioxide emissions - what long-term impact would the iron have on CO_2?

To answer those we need to be able to quantify how iron loading affects export fluxes of carbon and associated elements. This project does just that, measuring changes in the export of particulate organic carbon and particulate organic nitrogen, using the naturally occurring radionuclide thorium-234 (^{234}Th) during the Southern Ocean Iron Experiment (SOFeX). Using time-series profiles of ^{234}Th obtained both within and beyond the SOFeX study area, we will study how iron loading and its impact on community structure affects the export response. We will also calculate how adding iron impacts both carbon and nutrient fluxes.

Information on the export response of the upper ocean to iron enrichment should provide valuable information necessary to address the two questions cited above. (00-288-0)

Measurement of combustion effluent carbonaceous aerosols in the McMurdo Dry Valleys.
Anthony D. Hansen, Magee Scientific Company.

Though Antarctica remains comparatively pristine, there is heightened awareness of the impact the human presence and scientific work being undertaken there could have. To continue a series of assessments of the long-term environmental impact of the U.S. Antarctic Program's operations, we plan to generate a database detailing the abundance of carbonaceous aerosols in the McMurdo Dry Valleys.

The Long-Term Ecological Research (LTER) study site in the McMurdo Dry Valleys supports a fragile, nutrient-limited ecosystem that could be significantly affected by human activities. Of special concern are deposits of particles from carbonaceous aerosols ("black carbon"). These could result from the exhaust of diesel power generators and helicopter operations within the McMurdo Dry Valleys; it is even possible that combustion products from McMurdo Station about 100 kilometers away could migrate to the study area. For three austral summers, we are deploying a real-time optical analyzer at the LTER site to measure the concentration of black carbon, polycyclic aromatic hydrocarbons, and other filterable organic compounds useful in fingerprinting combustion products. (OO-314-O)

Shipboard acoustic Doppler current profiling on *Nathaniel B. Palmer and Lawrence M. Gould.*
Teresa K Chereskin, Scripps Institution of Oceanography; Edward Firing, University of Hawaii.

Currents in the Southern Ocean have a profound influence on the world's oceans - and therefore upon global temperature and the planet's ecosystem - yet some remote regions receive little scientific attention. Using Doppler technology (sound-wave transmission and reflection), this project is exploring upper ocean current velocities. We are building a quality-controlled data set in one such sparsely sampled and remote region, which nonetheless appears to play a significant role in global ocean circulation. We will develop and maintain a shipboard acoustic Doppler current profiler (ADCP) program on board the USAP research ships *Nathaniel B. Palmer and Laurence M. Gould.*

Part of our long-term science goal is to characterize the temporal and spatial velocity structure in the Southern Ocean. This entails measuring the seasonal and annual changes in upper ocean currents within the Drake Passage and then combining this information with similar temperature observations, to see how the heat exchange varies and how it drives upper ocean currents. (OO-315-O)

Field experiments and modeling of the breakup of antarctic sea ice.
John P. Dempsey, Clarkson University.

The sea ice in Antarctica comes and goes with the seasons - from as little as 4 million square kilometers (sq km) in February to as much as 20 million sq km in September. For scientists this marks something of a moving target, and the internal dynamics of the ice pack could be much better described than they are at present. This project focuses on how the antarctic sea-ice cover responds to stresses applied by wind and ocean waves, and how the temperature distribution within the sea ice affects these responses.

Researchers will conduct experiments on the deformation and fracture of sea ice in McMurdo Sound by applying a series of controlled stresses and observing their effects. A key effect is the initiation and growth of microcracks within the ice; large ice floes do not fracture in the same way as small ones do. Thus, for experiments to yield information that is valid for the larger scales that concern scientists, the test scales must be fairly large, some tens of meters. With these maneuvers we hope to gain detailed information on the microstructure of the ice (such as crystal structure, brine channels, and other flaws in the ice fabric) and establish a sound theoretical framework to guide experimental work and the generation of models.

In one component of this project, we are collaborating with the New Zealand Antarctic program; that effort concerns the fracture mechanics of fatigue crack propagation, the use of microstructural observations to verify magnetic resonance measurements of the structure of inclusions in the ice, and the acoustic emissions of fracture zones. (OO-316-O)

Record of atmospheric photochemistry in firn at South Pole.
Roger Bales and Joseph R. McConnell, University of Arizona Desert Research Institute, University of Nevada.

Scientists are eager to develop models about Earth's history, based on their knowledge of current, active dynamic processes. One such process vital to the Earth is photochemistry, how the sun's radiant energy affects conversion of oxygen in the atmosphere. By measuring and interpreting the hydrogen peroxide, formaldehyde, and nitric acid concentrations in the snow and firn at South Pole station, we hope to develop a credible history of the oxidation capacity of the atmosphere over the last two centuries. We also hope to evaluate methods that will confirm statistically significant changes in the concentration of these species over that time.

Amundsen-Scott South Pole Station is ideal for this work. The extreme cold makes the chemistry relatively simple; the NOAA Climate Modeling and Diagnostics Laboratory provides a context of high quality meteorological and chemical data; and the station is staffed continuously so that samples can be taken year-round.

We will sample air and near-surface snow throughout the year; during the summer, we will sample and analyze snow pits and firn cores and will model the air/snow chemistry to try to explain the observed concentrations in the firn. The summer conditions will also permit us to sample two snow pits around the perimeter of the snow stake field intensively (for accumulation observations), a process that will establish markers to maintain time control for stratigraphic and chemical horizons. During earlier work at South Pole and in central Greenland, we have developed and tested physically-based models of air/snow exchange of hydrogen peroxide. This project extends that work. (OO-324-O)

Particle export and remineralization in the Southern Ocean south of Australia: A Woods Hole Oceanographic Institute contribution to the Australian SAZ project.
Susumu Honjo, Woods Hole Oceanographic Institute.

Carbon dioxide (CO_2) - the single most abundant greenhouse gas - is a crucial variable in global atmospheric calculations and has been increasing a half percent a year for a decade. However, data for 200,000 years shows that CO_2 tracks with global temperature changes; and we have been in an historical period of global warming for over 25 years. Aside from the question of whether CO_2 spikes cause - or are caused by - the temperature shift, another basic issue concerns the extent of CO_2 that is anthropogenic (that is, from man-made, industrial sources).

This project is developing data to document whether intermediate depth water masses that are ventilated in the high southern latitudes can provide a temporary reservoir for anthropogenic CO_2. Shedding light on that question will help scientists understand the role of this region in the long-term trends - and the inter-annual variability - of atmospheric carbon-dioxide levels.

We will deploy and maintain a deep-sea sediment trap mooring in the Polar Frontal Zone south of Australia; this mooring complements a similar one in the Subantarctic Zone deployed by the Australian Antarctic Cooperative Research Center. We are using a radionuclide technique to evaluate the efficiency of the sediment traps and will develop data on the production of particulate matter, remineralization, and export.

Mesoscale, seasonal and inter-annual variability of surface-water carbon dioxide in the Drake Passage.
Taro Takahashi, Lamont-Doherty Earth Observatory, Columbia University.

The Southern Ocean provides an important component of the global carbon budget. Cold surface temperatures - with consequent low vertical stability, ice formation, and high winds - produce a very active environment where the atmospheric and oceanic reservoirs readily exchange gaseous carbon. The Drake Passage is the narrowest point through which the Antarctic Circumpolar Current and its associated fronts must pass; this so-called chokepoint provides the most efficient site to measure the latitudinal gradients of gas exchange.

Working from the R/V *Laurence M. Gould*, we will use equipment designed to measure both dissolved carbon dioxide (pCO_2) and occasional total carbon dioxide in the surface waters during transects of the Drake Passage. This work extends similar measurements made aboard R/V *Nathaniel B. Palmer*, and complements other data collected on surface temperatures and currents. These several data sets, supplemented by satellite imagery, will enable scientists to make estimates of the net production and carbon export by the biological community, as well as the basic targets - a quantitative description of the sources of pCO_2 variability and a calculation of CO_2 fluxes between the ocean and the atmosphere.

Natural iron fertilization of the Southern Ocean from melting sea ice.
P. Ross Edwards and John Donat, Old Dominion University.

Sea ice acts as a natural depository for wind-borne dust, which often carries iron into the ecosystem, thus spurring phytoplankton production. But there is currently no reliable information on the magnitude of this phenomenon in the upper layers of the Southern Ocean; despite the fact that simple flux calculations suggest this could be the dominant iron source, as much as three times greater than all other sources combined.

Taking advantage of an October 2001 cruise of the Australian icebreaker *Aurora Australis*, we will investigate the concentration of biologically active iron in the sea ice and its snow cover. Our objective is to evaluate both the concentration and the bioavailability of iron in the seasonal sea ice of the Southern Ocean south of Australia. Sample data - when combined with other sea-ice observations and sea-ice drift models - should greatly enhance our knowledge of antarctic iron biogeochemistry.